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Source: *Estuaries*, Vol. 2, No. 3 (Sep., 1979), pp. 154-163
Published by: Coastal and Estuarine Research Federation
Stable URL: http://www.jstor.org/stable/1351729
Accessed: 03/08/2010 14:01

Estuaries Vol. 2, No. 3, p. 154-163 September 1979

The Utilization of an Intertidal Salt Marsh Creek by Larval and Juvenile Fishes: Abundance, Diversity and Temporal Variation

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ABSTRACT: The utilization of an intertidal salt marsh creek in South Carolina during January 1977 was determined by sampling every third ebb tide for 13 days. All fishes leaving the creek during that period were captured in a channel net. This procedure produced a time-series of samples which permitted analysis of the fish community occupying the intertidal creek at all times of day and night.

A total of 14,730 larval, juvenile, and adult fishes comprising at least 22 species in 16 families were collected. The most common larval and juvenile fishes were *Leiostomus xanthurus, Mugil* spp., *Myrophis punctatus* leptocephali, *Lagodon rhomboides, Paralichthys* spp., and *Micropogon undulatus.* Catch sizes for all species varied widely between samples. No diurnal-nocturnal pattern in catches was evident for *L. xanthurus, Mugil* spp., *L. rhomboides* and *M. undulatus. M. punctatus* was taken in large numbers only when the flood tide occurred during the day, while more *Paralichthys* spp. larvae were taken in late afternoon-evening flood tide samples. The most common invertebrate, *Palaemonetes pugio,* was taken in large quantities only in late afternoon-night flood tide samples.

Three diversity indices were computed for each sample. Values for all indices varied widely between successive samples.

The results emphasize a high degree of utilization of the intertidal creek habitat by larval and juvenile fishes. The diurnal-nocturnal activity patterns of some species, and the wide variation in catch size of the other species can permit use of the intertidal salt marsh habitat with reduced competition for available space and energy.

Introduction

Larval and juvenile fishes of many species depend on salt marshes as important nursery grounds. The abundance of food, and the shelter offered by the marsh itself, provide such an excellent habitat for young fishes that many of the commercially important species on the east coast of the United States have evolved life history patterns that utilize marshlands and estuaries as a habitat during the early life history stages. McHugh (1966) estimated that approximately two-thirds of the catch of commercially important fishes are dependent on the estuarine habitat for the growth of the young fishes.

The fact that larval fishes are dependent on the salt marsh habitat is readily observable. However, quantitative estimates of the role that the larval and juvenile fishes play in the habitat, their behavioral patterns, and their actual abundance in the marsh are poorly understood. This study is primarily intended to examine the utilization of the intertidal creek habitat of the marsh by the immature fish fauna present in the South Carolina salt marsh system in mid-winter.

Intertidal creeks in the salt marsh are transient habitats that have only recently been investigated. Burns (1974) studied larval fish communities in the North Inlet estuary, South Carolina, by using a weir to collect

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0160-8347/79/030154-10$01.50/0

fishes in an intertidal creek. More recently, Bozeman and Dean (in press) used a net modified from the channel net design of Lewis et al. (1970), for a bimonthly sampling program that examined the larval fish fauna in the North Inlet estuary over a nine-month period.

The net used by Bozeman and Dean (in press) has shown potential as a tool for accurate assessment of the fish fauna in salt marsh creeks. Avoidance of the net by larvae is apparently eliminated, a large volume of water can be sampled with relative ease, the uncertainty of variable towing velocity on nets is removed, and a more quantitative method to estimate species abundance can be developed.

It is obvious that the methodology involved in examining the larval and juvenile fish communities is, at present, imprecise and perhaps misleading. Towed and stationary plankton nets often introduce biases against fishes able to avoid nets and benthic species not found in the water column. Day-night differences in avoidance reactions and movement patterns add to the present confusion (Graham and Venno 1968; Lewis and Mann 1971; Lewis and Wilkens 1971; Wilkens and Lewis 1971; Graham et al. 1972; Pacheco and Grant 1973; Bozeman and Dean, in press). The present study was designed to examine the larval fish community of an intertidal creek in an attempt to avoid such problems. An intensive sampling schedule was developed to test for day-night differences in the catch, and enable a measure of the day to day variation in the catches.

A portion of this work was supported by Grant No. 10640051 from the Coastal Plains Regional Commission to J. M. Dean. This is Contribution No. 234 of the Belle W. Baruch Institute of Marine Biology and Coastal Research.

Materials and Methods

Study Area

This study was conducted in Bozuz Creek in the North Inlet estuary (Fig. 1) in George-

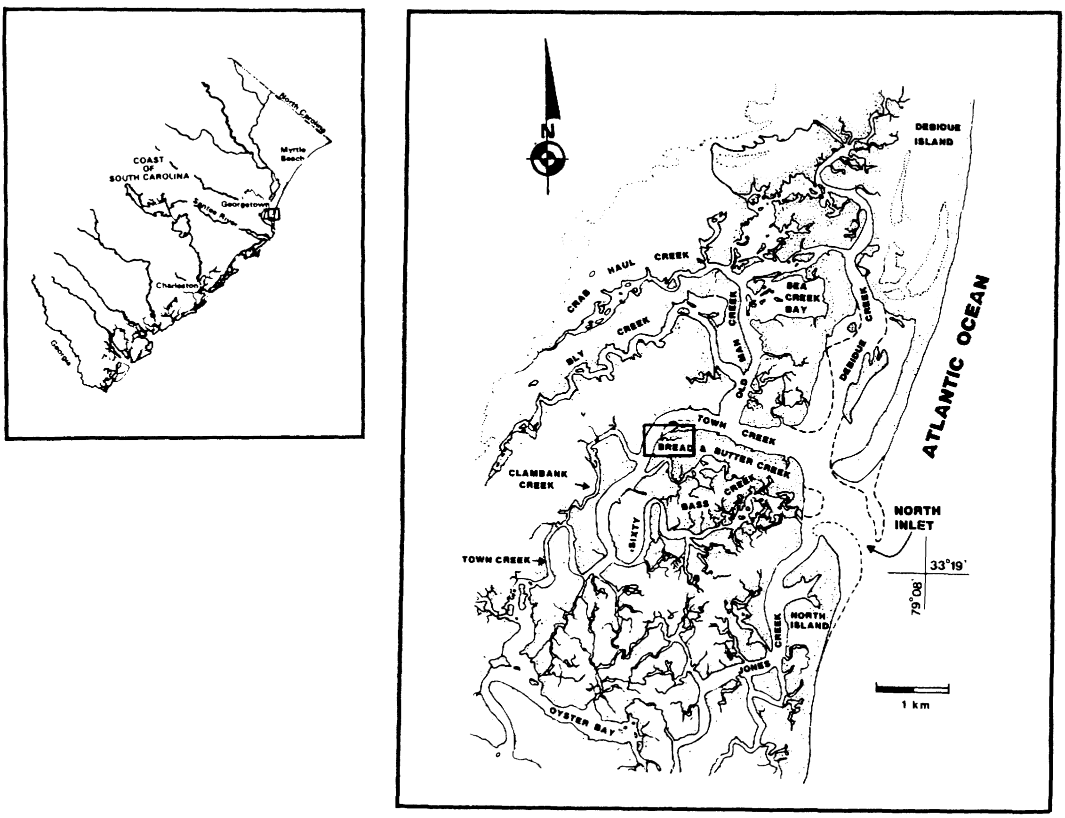

Fig. 1. North Inlet estuary, Georgetown, S.C. Small inset on large map shows the location of Bozuz Creek.

town County, South Carolina. This bar-built high-salinity estuary encompasses about 28 km^2 of *Spartina* spp. and *Juncus roemerianus* salt marsh, and is relatively free of human disturbance.

The marsh is flushed by semi-diurnal tides through the North Inlet channel, with an average tidal range of 1.5 m. However, the tidal height and duration are greatly affected by wind speed and direction. Salinity at the sample site during the study ranged from 25‰ to 32‰, ebb tides varied in duration from 4.5 to 6.5 hours, and tidal height varied from 1.2 to 1.6 m.

Bozuz Creek is an intertidal creek that drains into the main channel of Town Creek, and is almost completely dry at low tide. The creek bed is approximately 250 m long, 5 m wide at its mouth, with mud banks up to 1.5 m high, and a drainage area of about 1.67 hectares of *Spartina alterniflora* marsh. This creek was previously used as the primary sampling site for a nine-month survey of the larval fishes of the North Inlet estuary (Bozeman and Dean, in press).

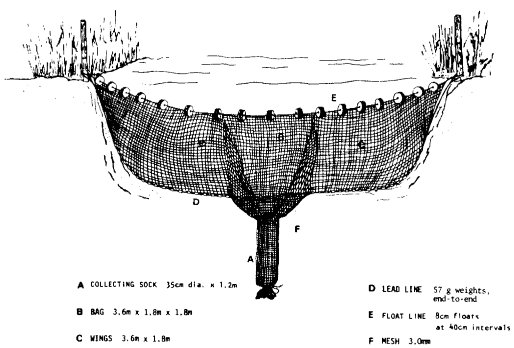

Fig. 2. Channel net, *in situ*. Net was placed in Bozuz Creek at slack high tide and removed at low tide.

Sampling Apparatus

A modified channel net (Fig. 2) was used in the sampling of Bozuz Creek. The net was designed to block the entire creek and capture all fishes exiting with the ebbing tide. The 3 mm "Delta Grade" mesh net (manufactured by the Nylon Net Co., Memphis, Tennessee) was set in Bozuz Creek at slack high tide by tying the ends of the lead and float lines to supporting posts driven into each bank of the creek. Two supplemental 10 kg weights were placed along the lead line to prevent lifting of the net off of the bottom during maximum ebb tidal velocites.

Sampling Schedule

One of the objectives of this study was to examine the diurnal variations in the presence and movement of fishes in the creeks. Every third ebb tide was fished over a period of 13 days from 1 January to 12 January 1977. This produced eight sampling periods that began approximately 2.5 hours apart over a 24-hour cycle (Table 1, Fig. 3).

Sample Analysis

All samples were immediately sorted to remove *Spartina* and algal debris, and all animals were then fixed in 10% formalin in seawater. Most fishes were sorted into species, but for three genera this was impractical, and they were identified only to genus; flounder larvae (*Paralichthys* spp.), juvenile mullet (*Mugil* spp.), and juvenile pipefish (*Syngnathus* spp.). The criteria and terminology of Lippson and Moran (1974) were used to sort and describe the species. Wet weights of fishes and invertebrates in the samples were determined to the nearest 0.1 g. Standard

TABLE 1. Sampling schedule and environmental data.

Date	No.	Approx. Beginning of Flood Tide	Time of Sample (Ebb tide)	Tidal Range (m)	Air Temp. (C)	Water Temp. (C)	Salinity (‰)
1 Jan.	1	11:30	17:35-21:35	1.22	3	7.5	25
3 Jan	2	01:00	07:02-12:45	1.17	4	8.5	29
4-5 Jan.	3	13:45	19:45-00:35	1.27	3	7.8	27
6 Jan.	4	02:00	09:05-15:30	1.55	−6	8.2	29
7-8 Jan.	5	15:15	21:15-03:20	1.24	5	8.2	29
9 Jan.	6	05:15	11:20-16:45	1.63	7	8.5	32
12 Jan.	7	19:45	01:40-06:05	1.42	−2	7.0	28
12 Jan.	8	06:05	13:40-18:00	1.14	10	8.1	29

Temperature and salinity data taken at the mouth of Bozuz Creek at the beginning of each sample.
Sunrise at approximately 07:00, sunset approximately 17:50.

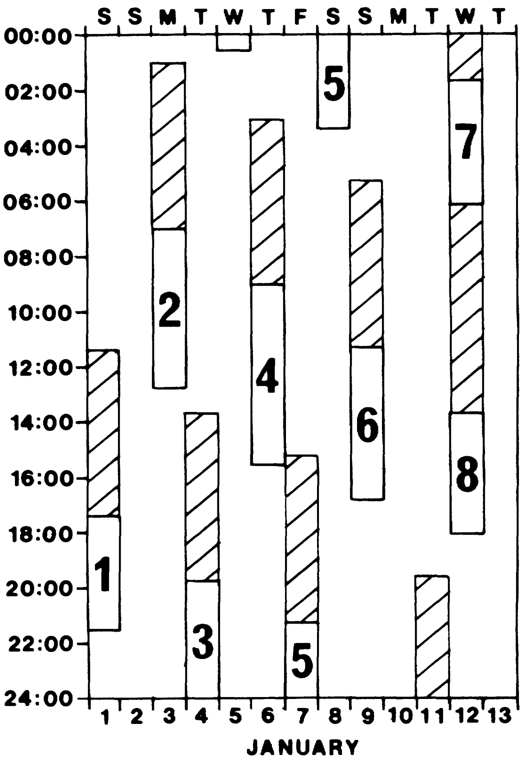

Fig. 3. Sampling schedule. Hatched blocks = approximate times of loading of fish into Bozuz Creek (flood tide); numbered blocks = collection times of fish moving out of Bozuz Creek (ebb tide).

lengths of the fishes were measured by placing the fish on a transparent grid, marked in mm, and illuminated from below. For large numbers of specimens of a single species in a sample, a subsample of 100 randomly chosen individuals was measured.

Three diversity indices were calculated for all samples (Dahlberg and Odum 1970). The Shannon-Weaver function ($H' = -\sum P_i \ln P_i$, where P_i = the proportion of individuals in the i^{th} species) measures changes in species number and species evenness. Species richness was computed as $D = (S - 1)/\ln N$, where S = the number of species in the sample, and N = the total number of individuals. Finally, Pielou's measure of "evenness" was computed, where $J = H'/\ln S$.

To test for statistical differences between samples (both in terms of numbers of fishes and in diversity indices), the samples were divided into two groups; those that began in darkness (samples 1, 3, 5 and 7), and those that began in daylight (samples 2, 4, 6 and 8). Differences between the two groups were evaluated with a two-tailed Mann-Whitney U-Test, with $\propto = 0.05$.

Results

A total of 14,730 fishes, of at least 22 species, and a total biomass of 6,063 g were taken in this study. In addition, seven species of invertebrates, with a total biomass of 5,533 g, were collected. A total of 11,051 immature fishes, comprising at least 13 species, were the focus of this investigation. The catch data for each of the eight sampling periods are presented in Table 2. Atlantic silversides, *Menidia menidia,* and bay anchovy, *Anchoa mitchilli,* dominated the catch of adult fishes in the creek. Catch size varied widely between samples; presumably, this is a reflection of the schooling behavior of these species. Of the larval forms present, six species made up 99% of the total catch of immature fishes: larval spot, *Leiostomus xanthurus*; juvenile mullet, *Mugil* spp.; the leptocephalus of the speckled worm eel, *Myrophis punctatus*; larval pinfish, *Lagodon rhomboides*; larval flounders, *Paralichthys* spp.; and larval Atlantic croaker, *Micropogon undulatus.*

Invertebrates made up nearly 50% of the total biomass collected. The most important invertebrate was the grass shrimp, *Palaemonetes pugio*, which accounted for 97% of the total invertebrate biomass. Immature blue crabs, *Callinectes sapidus*, were also relatively common in the sampling.

Total numbers of larval fishes per sample are shown in Figure 4a. The samples are arranged on a 24-hour scale, with each sample represented by a bar at the time corresponding to the start of each sample. For example, sample 7, taken on 12 January, started at 01:40; sample 2 started at 07:02 on 3 January; sample 4 started at 09:05 on 6 January, etc. It is important to remember that the data represent the fishes that moved into the creek with the flood tide, or within approximately the six hours *prior* to the start of each sample.

Larval spot, with 7,382 specimens (10.5 to 17 mm SL), was by far the most abundant species taken. The distribution of spot in the eight samples (Fig. 4b) showed no apparent

TABLE 2a. Bozuz Creek catch; adult fish numbers and biomass (wet weight).

Rank	Species	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Total
1	*Menidia menidia*	16	90	255	49	20	0	1785	0	2215
		23.5g	131.5g	487.7g	72.3g	31.3g	—	3768.0g	—	4514.3g
2	*Anchoa mitchilli*[a]	0	585	122	22	16	23	235	8	1011
		—	73.0g	14.5g	2.2g	10.5g	2.4g	32.6g	0.6g	135.8g
3	*Alosa aestivalis*	0	168	24	1	5	0	1	0	199
		—	207.3g	31.2g	1.4g	8.1g	—	1.5g	—	249.5g
4	*Dorosoma petenense*	1	70	6	1	0	0	2	0	80
		2.4g	163.8g	13.5g	2.2g	—	—	4.2g	—	186.1g
5	*Fundulus majalis*	1	0	31	4	1	0	18	0	55
		0.7g	—	35.0g	3.5g	0.6g	—	17.6g	—	57.4g
6	*Gobionellus shufeldti*[a]	31	1	4	0	4	0	13	1	54
		4.5g	0.5g	1.2g	—	0.3g	—	2.2g	0.1g	8.8g
7	*Brevoortia tyrannus*	0	4	4	1	9	1	1	0	20
		—	37.4g	25.5g	5.7g	41.4g	4.8g	4.4g	—	119.2g
8	*Fundulus heteroclitus*	5	1	11	0	0	0	1	1	19
		3.4g	0.6g	11.4g	—	—	—	0.8g	2.6g	18.8g
9	*Gobionellus boleosoma*[a]	3	1	0	0	2	0	4	0	10
		1.7g	0.2g	—	—	0.9g	—	1.4g	—	4.2g
10	*Gobiosoma bosci*[a]	2	2	2	0	2	0	1	0	9
		2.0g	0.2g	0.9g	—	1.7g	—	0.1g	—	4.9g
11	*Gobiosoma ginsburgi*[a]	0	0	1	0	2	0	3	0	6
		—	—	0.3g	—	0.2g	—	0.9g	—	1.4g
12	*Myrophis punctatus*	0	0	0	0	1	0	0	0	1
		—	—	—	—	1.1g	—	—	—	1.1g

[a] mixed assemblage of adults and a few immature individuals.

TABLE 2b. Bozuz Creek catch; larval and juvenile fish numbers and biomass (wet weight).

Rank	Species	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Total
1	*Leiostomus xanthurus*	24	3055	954	724	214	896	817	698	7382
		0.9g	121.6g	38.3g	29.6g	9.7g	40.7g	34.5g	31.2g	306.5g
2	*Mugil* spp.	66	340	121	86	211	169	90	13	1096
		12.0g	51.3g	20.4g	14.3g	31.3g	25.6g	13.3g	2.7g	170.9g
3	*Myrophis punctatus*	23	165	40	52	31	263	27	435	1036
		3.3g	31.7g	8.4g	10.0g	6.4g	55.1g	5.1g	91.0g	211.0g
4	*Lagodon rhomboides*	2	26	77	10	146	61	53	326	701
		0.05g	0.8g	2.5g	0.3g	4.7g	1.9g	1.3g	12.8g	24.3g
5	*Paralichthys* spp.	51	29	226	13	83	6	165	16	589
		1.4g	0.6g	6.1g	0.3g	2.2g	0.1g	5.3g	0.3g	16.3g
6	*Micropogon undulatus*	1	49	41	16	83	10	6	2	208
		0.07g	5.4g	7.8g	1.2g	1.5g	0.2g	1.0g	0.04g	17.3g
7	*Urophycis floridanus*	0	0	3	1	9	0	7	0	20
		—	—	2.6g	0.3g	7.5g	—	3.1g	—	13.5g
8	*Brevoortia tyrannus*	0	1	0	1	1	2	1	0	6
		—	0.04g	—	0.04g	0.04g	0.07g	0.04g	—	0.23g
9	*Syngnathus* spp.	0	0	0	0	3	1	1	0	5
		—	—	—	—	0.2g	0.04g	0.2g	—	0.44g
10	*Rissola marginata*	0	0	0	0	2	0	0	0	2
		—	—	—	—	0.5g	—	—	—	0.5g
11	*Opsanus tau*	1	0	0	0	0	0	0	0	1
		0.4g	—	—	—	—	—	—	—	0.4g
12	*Astroscopus y-graceum*	0	0	0	1	0	0	0	0	1
		—	—	—	0.3g	—	—	—	—	0.3g

day-night pattern in the size of the catch. Sample 2 had exceptionally large numbers of specimens, while samples 1 and 5 contained few specimens. Each of the five other samples produced similar numbers of spot, with an average of about 800 individuals. Analysis of length-frequency distributions of larvae taken throughout the sampling period showed an increase in average length of captured specimens of 0.1 mm/day.

A total of 701 larval pinfish were collected (10.5 to 15.5 mm SL). The catches of pinfish varied widely between samples, but no day-night pattern in the number of individuals collected was evident (Fig. 4c).

The 1,096 juvenile mullet collected ranged in size from 21 to 24 mm SL. Wide variation in catch size was apparent, but no day-night pattern was shown (Fig. 4d).

A total of 208 larval and juvenile Atlantic croaker were taken. In most samples, the specimens were of a widely mixed size range,

TABLE 2c. Bozuz Creek catch; total fish numbers, biomass (wet weight) and diversity index values.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Total
Total number of immature fish/sample	169	3666	1462	904	784	1408	1168	1490	11,051
Total biomass of immature fish/sample	18.2g	211.5g	86.1g	56.2g	64.2g	123.7g	63.9g	138.0g	762.0g
Number of species of immature fish/sample	8	8	7	9	11	8	10	6	13
Diversity of immature fish catches = H′	1.42	0.65	1.14	0.77	1.73	1.06	1.03	1.15	1.15
Evenness of immature fish catches = J	0.68	0.31	0.59	0.35	0.72	0.51	0.45	0.64	0.45
Species richness of immature fish catches = D	1.36	0.85	0.82	1.18	1.50	0.97	1.27	0.68	1.29
Total number of fish/sample	228	4588	1922	982	846	1432	3232	1500	14,730
Total biomass of fish/sample	56.4g	826.1g	707.3g	143.6g	160.3g	130.9g	3897.6g	141.3g	6063.5g
Total number of species	15	16	17	14	19	9	20	8	22
Total diversity = H′	1.96	1.24	1.72	1.06	1.99	1.13	1.34	1.18	1.71
Total evenness = J	0.72	0.45	0.61	0.40	0.68	0.52	0.45	0.54	0.55
Total species richness = D	2.58	1.78	2.12	1.89	2.67	1.10	2.35	0.96	2.29

TABLE 2d. Bozuz Creek catch; invertebrate numbers and biomass (wet weight).

Species	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Total
Palaemonetes pugio	984.9g	73.9g	2162.7g	2.0g	817.9g	7.2g	1382.8g	6.7g	5438.1g
Callinectes sapidus	11	1	35	20	60	7	0	1	135
	10.3g	0.8g	31.5g	6.0g	17.8g	0.7g		0.3g	67.4g
Cerebratulus spp.	0	0	0	0	14.7g	0	0	0	14.7g
Glycera spp.	1	0	0	0	5	0	1	0	7
	2.3g	—	—	—	5.9g	—	0.4g	—	8.6g
Penaeus setiferus	0	0	0	0	1	0	0	0	1
	—	—	—	—	2.2g	—	—	—	2.2g
Loliguncula brevis	0	0	0	2	0	0	0	0	2
	—	—	—	1.3g	—	—	—	—	1.3g
Alpheus spp.	0	0	0	0	4	0	0	0	4
	—	—	—	—	0.4g	—	—	—	0.4g
Total invertebrate biomass/sample	997.5g	74.7g	2194.2g	9.3g	858.9g	7.9g	1383.2g	7.0g	5532.7g
Total biomass (fish + invertebrate)/sample	1053.9g	900.8g	2901.5g	152.9g	1019.2g	138.8g	5280.8g	148.3g	11596.2g

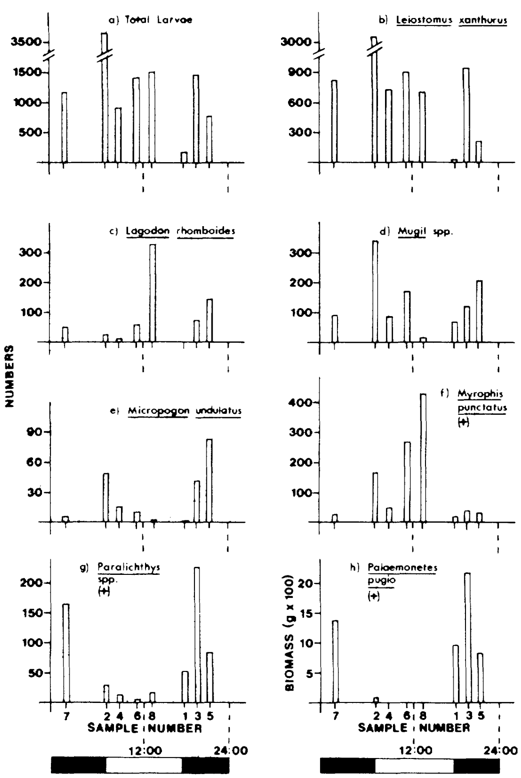

Fig. 4. Catches of larval and juvenile fishes and dominant invertebrate species. Sample numbers are arranged on a 24-hour scale, as discussed in text. (+) = significant difference between day samples (Nos. 2, 4, 6, and 8) and night samples (Nos. 1, 3, 5, and 7), as evaluated by the Mann-Whitney U-Test with $\alpha = 0.05$.

from 8.5 to 29.5 mm SL. Sample 7 included one specimen of 40 mm SL and 0.9 g. Sample 5 was unusual in that 81 out of the 83 specimens were small, ranging from 8.5 to 12.0 mm SL. No day-night patterns were apparent in the catch sequence (Fig. 4e).

The leptocephalus larvae of the speckled worm eel exhibited a diurnal variation in catch, with greater catches made during daylight hours (Fig. 4f). The 1,036 specimens ranged from 51 to 62 mm SL. Several metamorphosing leptocephali were taken with a 0.75 m plankton net in collections not included in this report.

Larval flounders showed a definite increase in availability in night samples over day samples (Fig. 4g). The 589 specimens ranged in size from 7.5 to 14 mm SL. Larvae maintained in an aquarium for several days were generally found swimming in the water column at night, and resting on the bottom during the day.

Nineteen out of the 20 juvenile southern hakes (27 to 53 mm SL) were collected in night samples. This was the only species that obviously fed on larval fishes, but mysids comprised the majority of the hake gut contents. The voracious feeding and rapid

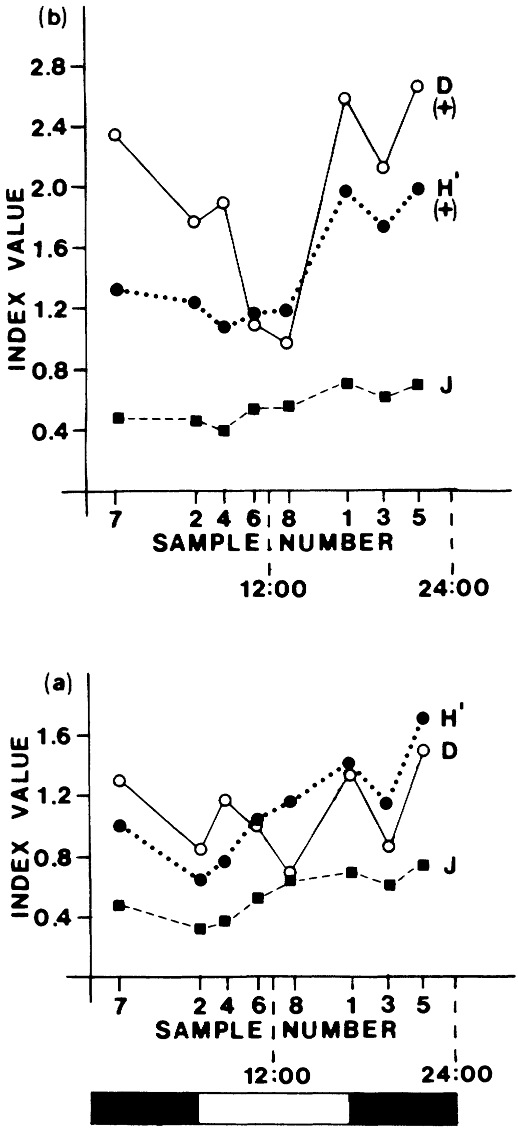

Fig. 5. Diversity values, arranged on a 24-hour scale, as discussed in text. a) larval and juvenile fishes only; b) all fishes; H' = Shannon-Weaver diversity index; J = evenness; D = species richness; (+) = significant difference between day and night samples, as evaluated by the Mann-Whitney U-Test with $\alpha = 0.05$.

growth of southern hake was observed for a specimen held in an aquarium and fed at least once a day with frozen silversides until satiated. Within five weeks, it grew from 35 to 100 mm SL, a rate of growth of 13 mm/ week.

The grass shrimp dominated the invertebrate component of the samples. This species showed a striking nocturnal emergence, and was not taken during the daytime (Fig. 4h). Emergence started in the late afternoon, and the shrimp moved throughout the water until early morning. It is probable that this species burrowed into the sediments during the day.

All three diversity indices showed wide variations between samples. Figure 5 presents the diversity indices calculated for each sample, with the values arranged along a 24-hour scale, as discussed above. No significant day-night trends in the index values were indicated when only the larval and juvenile fishes alone were used in the computations (Fig. 5a). However, when adult fishes were added to the computations (Fig. 5b), diversity (H′) and species richness (D) were significantly higher (as evaluated by a Mann-Whitney U-Test) in night samples than day samples.

Discussion

Most previous examinations of the larval fish communities in estuarine waters suffered from inadequate sampling schedules and biases in the capture techniques. While initial surveys of the larval communities can be accomplished with monthly samples, the abundance and movement patterns of the various species present are poorly illustrated by such samples. This report clearly illustrates that day-to-day variation in catches and day-night differences in catches can greatly affect estimation of relative abundance, movement patterns and diversity indices.

This study examined the fish community at all hours of the day, but the 13-day duration of the study superimposed an additional bias that must be considered when examining the results: the absolute number of larvae within the North Inlet estuary will probably change over a two-week period. Estuaries are dynamic systems subject to continual larval fish immigration from the ocean, emigration from the estuary, shifts in the location of larvae in the water column, and larval mortality. In the case of speckled worm eels, the metamorphosis of the leptocephali into elvers, and their subsequent adoption of a benthic existence, will change that species' availability in the water column (Bozeman and Dean, in press).

Distinct nocturnal-diurnal differences in catches were noted. Flounders and grass shrimp were taken in large quantities only in night samples, while speckled worm eels were taken in the intertidal creek in large numbers in the daytime. Specimens of the first two species were observed to be active and swimming at night in aquaria, and sedentary during the day. This activity pattern is probably responsible for the pattern noted in catch sizes in the eight samples. For the speckled worm eels, however, the reasons for the diurnal utilization of the intertidal creek are currently unknown.

Other species of larval fishes did not show such distinct diurnal patterns, but large variations were common between catches, particularly with spot and pinfish. The extreme fluctuations in the size of the catches of various species is an observation that can best be explained by postulating schooling behavior in those species. Hildebrand and Cable (1930) reported that spot aggregated in schools until the fish reached 25 mm in length. Pacheco (1973) remarked that the schooling behavior of young mullet and their net avoidance behavior prevented adequate sampling of those species. This distribution pattern can account for the wide variations in catch size, as the number and size of schools entering the intertidal creek may be a more or less random event.

Comparisons can be made between the present data and that of Bozeman and Dean (in press), collected in early January 1975 in the same locality. They took three samples during that time period; a day-loaded sample on 4 January and samples on 7 and 16 January, when the flood tide took place in late afternoon and early evening. Both studies showed a higher day-time catch of speckled worm eel leptocephali, the definite nocturnal catch of flounders, and the wide range in the catch size for spot, pinfish, and mullet. Their indication that total larval catches were higher at night than during the day is not supported by the current study, which found a wide range in total catch size throughout the sampling period.

A general conclusion can be drawn from this study; if any one of the eight samples collected were examined as if it were a single monthly sample, it would lead to different conclusions about the relative abundance of the various species present. Results of monthly "day" and "night" sampling programs can only be considered as broad indicators of the fish community. It seems that there are two alternatives for accurately assessing the temporal nature of the community. Taking numerous samples at short intervals over a 24-hour period (Livingstone 1976) can permit adequate analysis of the fauna, but is difficult in an intertidal creek. The second possibility is the use of the time-series sampling conducted in this study, and used by Reis (1977) and Dean et al.[2] Although physically demanding, the data appear to provide a more accurate picture of the movement and schooling patterns of the fishes in an estuary.

Analysis of the diversity indices calculated here show that values can vary widely. No trends in the diversity values of the larval community were noted that cannot be explained by the randomness of the distribution of the fishes in any sample. When adult fishes are added to the computations, it appears that the adults utilized the intertidal creek primarily at night. Comparisons of the present data with the diversity calculations used on fish communities in previous studies raise some interesting considerations. Dahlberg and Odum (1970), in their study of the salt marsh large creek fish fauna in a Georgia estuary, stated that H′ exhibited a "dampened" seasonal cycle, with the highest H′ in winter and lowest in summer. J followed a more distinct pattern, with maximum evenness in the spring, and low evenness in late summer. These calculations were based on a series of one 15-minute trawl at each of four stations in three habitats, with samples taken once every three weeks. When the diversity values for all fishes in Bozuz Creek were examined, the difference between samples taken just 39 hours apart (samples 4 and 5) were equal to the maximum difference found between the seasons in Dahlberg and Odom's study. Subrahmanyam and Drake (1975) collected monthly samples of fishes at high and low tides in salt marshes in Florida. They noted large differences in H′ and D between high and low tide samples collected on the same day, but concluded that seasonal differences followed a pattern similar to that described by Dahlberg and Odum. Again, the variation of the indices over the year-long study was not much greater than the day-to-day variation found in this study. Thus, diversity measures might be misleading in describing highly mobile fish faunas, as sample-to-sample variation is greatly affected by the continual movement of the fish.

Much work remains to be done with the larval fishes in estuaries. Use of the channel net and a time-series sampling schedule is perhaps one of the best ways to develop better estimates of the true composition of the fish community. However, studies of behavioral and physiological functions, such as schooling, response to light, diet, and the energetics of the larvae of each species, are still necessary to properly assess the role of the larval fishes in estuaries.

We have found that large numbers of the young of important commercial and forage species of fish frequent the intertidal creek in the winter, while predatory fish were seldom taken. The tidelands are very productive and rich in detritus and, even though many of the young fish are not themselves detritivores, they benefit from that productivity as secondary consumers. The occurrence in the intertidal creek of the different species of larval and juvenile fishes at different times of the day, and seasons of the year probably enables these species to take maximum advantage of the energy-rich, predator free habitat of the intertidal creek.

[2] Dean, J. M., D. Hird, and B. Rogers. Production of fish in old rice fields of the Santee Delta. 1977 Progress Report to the Coastal Plains Regional Commission.

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